

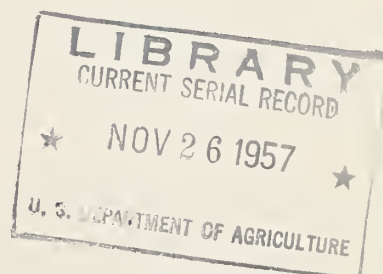
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TECHNICAL PROGRESS REPORT ON CURING

VIRGINIA TYPE PEANUTS,

1952-56

Agricultural Research Service

UNITED STATES DEPARTMENT OF AGRICULTURE

ESTABLISHMENT OF PROJECT

Prior to 1952 the Production and Marketing Administration through the Commodity Credit Corporation expended some funds for storage bins, corn shellers, driers, testing equipment, and various other items to promote the study of corn drying and storage at the Tidewater Field Station at Holland, Va. The help of the Divisions of Agricultural Engineering of the Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, was solicited to make some limited tests in cooperation with the Virginia Agricultural Experiment Station. Promising results from preliminary tests led to the development of a cooperative agreement between the Virginia Agricultural Experiment Station and the Bureau of Plant Industry, Soils, and Agricultural Engineering, the functions of which later became part of a new Agriculture Department unit, the Agricultural Research Service.

Dr. R. W. Young, Prof. C. E. Seitz, Dr. E. G. McKibben, Wallace Ashby, R. B. Gray, and Leo Holman organized a project agreement (August 1952) in which the Virginia station furnished office quarters, a shop building, some corn- and peanut-producing land, cooperative advice, and a limited amount of financial support. The then Bureau furnished professional-grade personnel, research equipment, project supervision, and an operating budget. G. B. Duke led the project on farm machinery and N. C. Teter assisted by R. L. Givens led the project on farm buildings. In the early stages, I. F. Reed assisted the farm machinery project in an advisory capacity, and Leo Holman, the farm buildings project. Later this general supervision became the responsibility of H. F. Miller, Head, Farm Machinery Section, and of Wallace Ashby, Head, and W. V. Hukill, Principal Agricultural Engineer, Farm Buildings Section, Agricultural Engineering Research Branch, ARS. This project organization permitted close cooperation on the harvesting and drying phases of the peanut work.

Although corn drying and storage research is also a part of the project work on farm buildings, only the peanut drying progress is reported in this publication.

CONTENTS

	<u>Page</u>
Introduction -----	1
Laboratory Equipment -----	2
Quality Scoring -----	2
1952 Curing Studies -----	4
1953 Curing Studies -----	5
Windrowing and Drying Effects on Quality -----	7
Drying at Constant Temperature Rise -----	7
Miscellaneous Tests -----	9
1954 Curing Studies -----	11
Windrowing and Drying Effects on Quality -----	11
Miscellaneous Tests -----	13
1955 Curing Studies -----	13
Windrowing and Drying Effects on Quality -----	14
Windrowing and Drying Effects on Costs and Returns -----	14
1956 Curing Studies -----	15
Use of Unheated Air -----	17
Miscellaneous Field Trials -----	17
Summary -----	19
Conclusions -----	21

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Appreciation is expressed also to George Duke, Agricultural Engineering Research Division, ARS, for his cooperation in the harvesting phases of the work without which many of these studies would not have been possible. Furthermore, appreciation is expressed to Dr. E. H. and Mrs. V. A. Toole, K. H. Garren, W. K. Bailey, and W. Welch of the Vegetable Crops Branch, Horticultural Crops Research Division, ARS, for shelling damage and germination studies for quality determination; to H. Reynolds, Head, Microbiology Branch, Human Nutrition Research Division, ARS, for palatability studies; to W. D. Hanson, Biometrician, Biometrical Services, Office of the Administrator, ARS; to the Department of Biochemistry and Nutrition of the Virginia Polytechnic Institute for fat acidity determination; to those commercial companies who consigned driers used in field testing; and to those peanut processing companies who assisted in the work by testing end products for acceptability of their use.

TECHNICAL PROGRESS REPORT ON CURING
VIRGINIA TYPE PEANUTS,
1952-56 1/

By
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Agricultural Engineering Research Division 2/

INTRODUCTION

The term "curing" is used to describe the physiological change in peanuts from a freshly dug state to a condition suitable for storage or shipment. The traditional method of achieving this change is to stack wilted peanut vines on a stack pole in the field. Customarily these poles are equipped with cross-pieces nailed about 23 inches from the end of the pole so they will serve to hold the peanuts off of the ground after the pole is set up in the ground. About 55 to 65 stack poles to the acre are normal for the Tidewater Region of Virginia. The peanuts remain on these poles from 5 to 12 weeks until the moisture content within the peanut is lowered to a marketable level of 11 percent or below. The labor requirement of this method coupled with field losses led to a study of other methods of curing the peanut crop (figure 1).

In the course of studies, it is evident that mature peanuts cure easier and give a better product than immature peanuts. A peanut reaches maturity when, while vitally attached to the living parent plant, it reaches an approximate maximum size and ceases to increase in dry matter. Theoretically, all peanuts should be dug at the time of optimum maturity, but practically this is impossible because the peanuts on a vine do not all mature together. In a study of curing, therefore, it is essential to study field-run peanuts as they are harvested. Although no attempt was made to define chemical changes which occur in peanut curing, observations of characteristics of peanuts in curing indicate that a freshly dug peanut on a living plant must ripen before an acceptable end product will result from the cure. The ripening process requires the presence of water and a favorable environment. The objective of these studies was to determine practical methods of achieving good quality cured peanuts, and to find methods of applying these methods economically on the farm.

1/ Cooperative investigations of the Agricultural Engineering Research Division, Agricultural Research Service, USDA, and the Virginia Agricultural Experiment Station.

2/ Located at the Virginia Tidewater Research Station, Holland, Va.

To accomplish this objective, the work naturally fell into two main categories; namely, controlled tests in laboratory bins, and application trials in the field. In the laboratory tests, no aspects were studied unless a practical application was evident. Farm costs and farm methods of work played a constant role in the development of work plans.

Laboratory Equipment

The drying unit used in laboratory studies consisted of 16 test bins, each 14-5/8 inches square and 44 inches tall (fig. 2). Each of these bins was set on a lateral duct from a main air source. Each lateral was equipped with electrical heating elements to control either the temperature or the rise in temperature of the air passing through the lateral, and with a calibrated orifice plate with pressure taps on each side to measure the volume of air passed through each bin. With this system 16 different airflows and temperatures could be studied, or replicates could be made to study the variability of the test results. Moisture values were computed from the weight loss of peanuts held in a forced-draft oven at 190° F. for a period of 72 hours or longer. Temperature readings were made with copper-constantan thermocouples read with either a portable potentiometer or a 16-point recording potentiometer. Pressure readings for recording airflows were made with an inclined manometer equipped with a vernier for reading to one-hundredth of an inch of water.

Quality Scoring

Since the production of good quality peanuts was specified as the objective of the experiments, the first problem was to establish a quantitative method of comparing the quality of peanuts obtained from various curing methods. In 1952, a wide variety of tests resulted in a range of products from an entirely valueless to what appeared a very acceptable product. Of the various measurable attributes of the peanuts, shelling damage as found by W. A. Welch, Horticultural Crops Research Division, Agricultural Research Service, was considered the most important indicator of quality and was given a weight of 60 percent in determining the "quality." This was followed in order by germination, 20 percent; fat acidity, 15; and weather damage, 5 percent. These factors leave out one of the most important in quality scoring - flavor. Flavor does not readily lend itself to quantitative interpretation and seems to be associated with values of the attributes listed. The best values obtained in 1952 on any lot of peanuts tested were: Shelling damage, 12 percent; germination, 97.7 percent; fat acidity, 5; and weather damage, 2.6 percent. These values became the standards of the quality index, and all future tests were compared on this basis. When the quantitative data were formulated in the following manner in 1952 the test results ranged from a score of 1.19 to 3.82, the lower score being the best peanut.

$$\frac{(0.60) (\text{Shelling damage})}{12.0} + \frac{(0.20) (97.7)}{\text{Germination}} + \frac{(0.15) (\text{Fat acidity})}{5} + \frac{(0.05) (\text{Weather damage})}{2.6} = \text{Score}$$



Figure 1. Peanut stacks being cured by the normal method. (Temperatures within the stacks are being recorded.)

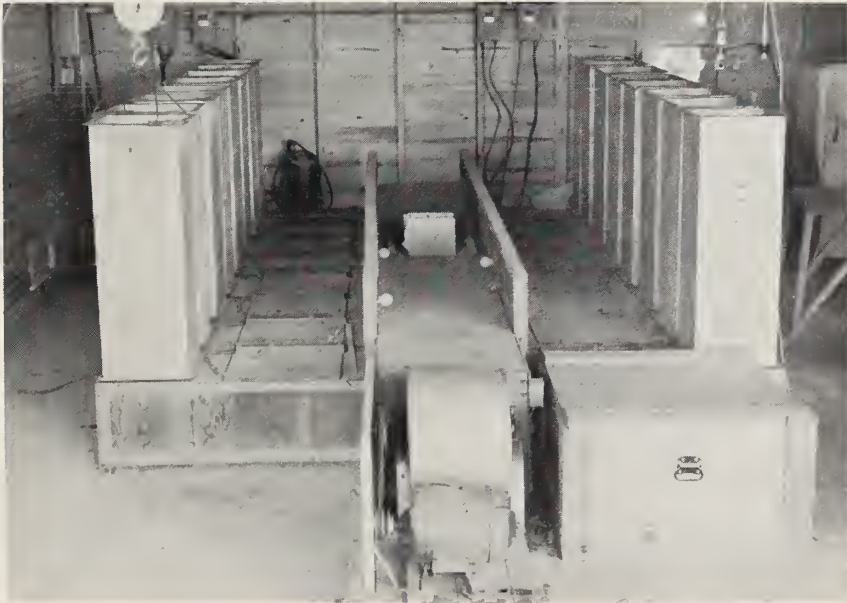


Figure 2. Laboratory bins used for study of peanut drying.

Since the scores are inverse in that a low score represents a better product, these scores were reorganized in linear relationship to obtain quality "grades." The best peanut in 1952, having a score of 1.19, was given a "grade" of 100 percent, and on this basis the poor score of 3.82 was given a "grade" of 31.1 percent since the ratio of 1.19/3.82 is 31.1 percent. All scores falling between these values were given a "grade" on the basis of the linear relationship, i.e. a straight line interpolation.

1952 CURING STUDIES

In 1952 preliminary setup of the equipment and initial probing into the best lines of attack gave valuable data, but very poor results on the peanuts obtained. The only acceptable product from the tests made this year (taking a quality "grade" of 95 percent or higher as acceptable) was from the stack-poled peanuts.

In the test bins, four main experiments were made:

Windrowing tests consisted of harvesting peanuts after they had been in the windrow 2, 4, and 6 days (fig. 3) and subjecting them to airflows of 2.5 and 12.0 cubic feet per minute (CFM) per cubic foot of peanuts as measured at the top surface of the bin. Temperature control of the air entering the peanuts was very poor. Recorded figures show a maximum entering air temperature of 106° F. in one of the bins, and all of them reached maximums of at least 95°. Minimums reached as low as 60.5°. To further confuse the results, a frost occurred on the night after the fourth day of windrowing and a severe killing frost occurred on the night after the fifth day of windrowing. The peanuts harvested on the sixth day were removed from the field soon after being subjected to a freeze. Furthermore, the peanuts were held in the bin until they dried to moisture content below 8 percent. The 59.3 percent moisture recorded at digging time dropped to 44.7, 41.0, and 29.8 percent after 2, 4, and 6 days of windrowing. By windrowing for 6 days, 74.2 percent of the work of water removal was accomplished.

These experiments led to the elimination of 2-day windrowing since it neither gave sufficient time for ripening nor dropped the moisture content to economical levels. The work pointed up the dangers of using a great temperature rise in the drying air, illustrated the bad results of frosting high-moisture peanuts, and demonstrated the difficulty of temperature control even in laboratory test bins.

Soaking in water for a period of 2, 4, and 6 days fermented peanuts freshly dug from the field. The peanuts released an odor like sour watermelon rinds and gave off a gas. The skin color of the soaked peanuts was very bleached and all of the products after drying were inedible. Moisture

contents of the peanuts removed from the soak were 66.8, 70.7, and 73.9 percent after 2, 4, and 6 days.

Refrigeration of freshly dug peanuts at temperatures of 35° and 55° F. for a period of 4 and 13 days indicated that some further work may be justified from an academic standpoint, but the applicability of the method at the present time is negative. The peanuts refrigerated 4 days at 55° gave very similar results to those refrigerated 13 days at 35°, indicating that the temperature at which peanuts are held influences some of the changes within the peanut.

Sulfur dioxide applied at the rate of 5 pounds per ton of green weight will not completely penetrate the peanut. However, a rate of 20 pounds per ton of green weight will completely penetrate and give an inedible product with a germination value of zero. Sulfur dioxide as applied cannot be recommended as a mold-inhibiting agent on freshly dug peanuts.

Miscellaneous tests consisted of use of low volume natural air on freshly dug peanuts, and the placement of small, medium, and large sacks of peanuts at two different moisture levels on a platform in the field; each of these small tests furnished helpful information.

Ventilating the pods of freshly dug peanuts with unheated air at the rate of 2.2 cubic feet per minute per cubic foot of peanuts resulted in much molding, but the flavor of the peanuts from the pods that escaped molding was quite good. This indicated that freshly dug peanuts can be dried satisfactorily in bulk bins if some means can be devised to keep mold from developing during the drying process.

Moistures of 43.2 and 34.3 percent at the end of 3 and 5 days in the windrow were used for the peanuts placed in bags on the open rack (fig. 4). Each bag was set apart from others so that air could circulate freely about the bag. The pods of the higher moisture peanuts molded quite badly, but the lower moisture peanuts were judged to have only 6.4 percent damage from the curing process. Peanuts treated in this manner could be successfully dried in the field if the initial moisture content was considerably lower and the rack was protected from rainfall.

1953 CURING STUDIES

Time before the harvest season allowed planning and preparation for the 1953 season. The main laboratory experiment (drying) was revised to employ 4 replications of the same airflow and temperature rise (see page 7) on peanuts windrowed and harvested after 4, 6, and 8 days in the field. The desired temperature rise of 20° F. was accomplished within plus or minus 3.6°. The experimental aim of flows of 5, 10, and 20 cubic feet of air per minute per cubic foot of peanuts averaged to 5.2, 11.6, and 22.8 in the actual testing.



Figure 3. Windrow curing of peanuts.



Figure 4. Bags of high-moisture peanuts placed on a rack for natural air drying.

Windrowing and Drying Effects on Quality

Results of windrowing tests showed that there was no significant difference at the 5 percent level between stack-poled and windrowed peanuts. Peanuts windrowed 6 days had significantly less shelling damage (2 percent level) than those windrowed 4 days; those windrowed 8 days showed significance at the 1 percent level. Since curing conditions of these peanuts were nearly identical, shelling-damage differentials are attributed to time in the windrow. The final moisture at the discontinuation of drying had a significant effect upon the shelling damage, the lower moistures giving more shelling damages than the higher. Therefore, the fact was established that it is better to discontinue drying as soon as possible after the peanuts reach a marketable moisture. In addition to the quantitative analysis of quality, previously described, the flavor of the peanuts as judged by individuals at the Tidewater Field Station and by experts of Planters and Lummis Peanut Companies ^{3/} showed that all of the peanuts windrowed for 4 days (9 trials) showed mild or flat flavor or lack of flavor, while peanuts windrowed for 6 days or longer (12 trials) showed normal flavor. No statistical method of organoleptic testing was used this year.

A study of the germination shows that windrowing and drying did not affect the viability of the seed. However, time in the field did affect the degree of dormancy. The longer the time in the windrow, the less the dormancy, and stack-pole peanuts were statistically less dormant than those windrowed. At planting time the difference in dormancy disappears and no difference in the field stands can be detected from peanuts handled by the different methods.

Drying at Constant Temperature Rise

When using a 20° F. temperature rise above ambient, the rate of ventilation and by consequence the rate of drying had no significant effect on the quality of the peanut. With flows varying as greatly as 5 to 20 cubic feet per minute per cubic foot of peanuts, there was no difference in the resulting quality. Lower flows gave less operating cost for the fuel and power requirements of drying, but at the same time gave slower drying, which in a practical installation would require greater overhead investment in buildings. Subsequent tests showed no significant differences in peanut quality as associated with rate of ventilation at other temperature rises, as long as sufficient drying potential is delivered to prevent mold development.

^{3/} Mention of companies in this paper does not imply recommendation or endorsement by the USDA over others not mentioned.

In reviewing the favorable results obtained from peanuts windrowed 6 days or longer, the fact that these peanuts were subjected to a constant temperature rise of 20° F. in the entering air must be regarded as an important part of the favorable results. Inasmuch as comparable experiments making attempts to control the temperature of the air by thermostat have repeatedly given dubious results, it is better to conclude that utilization of a constant temperature rise in the drying air is preferable to temperature control until further investigation disproves or unquestionably proves the merit of constant heat input into the drier.

Physical factors involved in the drying include such things as the amount of water to be removed, the static pressures involved, the amount of time and heat energy required for the removal of water, and the space required to house unit weights of peanuts. Claude K. Shedd at Iowa State College ran tests on the static resistance of peanuts to various airflows; these data are published in the Agricultural Engineers Yearbook along with data on grains.

In surveying the results of table 1 an accurate concept of the meaning of the rate of aeration is needed. The peanuts in the 1953 test were 3 feet deep, and the rate of aeration given in the table is for the top surface of the peanuts. Those below the surface layer are ventilated at geometrically greater rates. Therefore, the rates cited are the minimum rates of ventilation occurring in a bin.

Table 1. Drying rate of peanuts blown with air temperature 20° F. above ambient (Max. ambient 79° F., Min. 36° F., Av. 54° F.).

<u>Rate of Aeration CFM/ft.³</u>	<u>Drying Rate, % Dry-Basis Moisture Loss per hour</u>	<u>Drying Time from 35% to 8% - Hrs.</u>	<u>BTU Heat Input per Lb. Water Removed</u>
20	0.77	58	3,490
10	0.52	87	2,870
5	0.39	115	2,440

Average moistures at 4, 6, and 8 days in the windrow were 38.0, 34.5, and 30.8 percent. An analysis of the cost for fuel and power for drying showed a variation from \$5.86 per ton for peanuts windrowed only 4 days and dried with 20 CFM/ft.³ compared to \$2.77 per ton for peanuts windrowed 8 days and dried with 5 CFM/ft.³. The fuel and power cost is not considered as a major deterrent to the practice of artificial drying.

Miscellaneous Tests

A group of miscellaneous trials included drying of freshly dug peanuts with unheated air, the natural drying of freshly dug peanuts placed in open wire-mesh baskets to various depths, and the use of sodium hypochlorite as a mold inhibitor on freshly dug peanuts. Peanuts for these tests had an initial moisture of 54.8 percent.

Freshly dug peanuts when ventilated with unheated air flowing at the rate of 5 CFM/ft.³ gave surprisingly good results in this one test. Inasmuch as this bin was operated off one unheated lateral in a group of heated laterals, there may have been some pickup of heat from the other laterals. It was found that peanuts bulked to a depth of 1 inch in the wire-mesh baskets fully exposed in an open shed will cure out all right, but depths over 1 inch are excessive.

Sodium hypochlorite used in concentrations of 0.08 percent or greater indicated some inhibition of bacteria of the B. subtilus type.

Tests in 1953 on the use of five chemical defoliant prior to harvest were negative in regard to benefits on peanut curing.

Field trials of drying peanuts on the vine gave fair results but entailed too much labor. A 5-acre field was dug at a moisture content of 55.0 percent in the nuts and 74.6 percent in the vines. The nuts and vines had dropped to 23.8 and 27.6 percent, respectively, 5 days later, when 2.8 acres of the vines were loaded into a building 18 feet wide, 30 feet long, with 10-foot stud walls (fig. 5). During this process the hay loader broke down and it started to rain, but as the farmer was anxious to get the peanuts in, he went ahead, until it got too muddy. Actual moistures loaded into the barn were 30.8 percent in the nuts and 55.8 percent in the hay. The remaining 2.2 acres were put in 3 days later at moistures for the nuts and hay of 22.1 percent and 27.0 percent, respectively. The high-moisture, rain-wetted material that went into the barn presented a drying problem initially which was met by leaving a 5-gallon-per-hour nozzle in the kerosene burner. The high temperature used overdried the bottom of the peanut pile and led to a poor product from the standpoint of shelling damage.

With proper management this method of peanut harvest is preferred over the stack-pole method, but does not lend itself so well to labor reduction as picking from the windrow. The labor requirement was 19.9 man-hours and 6.2 tractor-hours per acre for the entire harvesting job from digging through picking. Further study of the method was discontinued.

A field trial of drying peanuts picked from the windrow (2 acres) gave excellent results. The peanuts were dug at 54.8 percent moisture and picked 6 days later at 27.5 percent moisture. A temperature rise of 12° F. was used with more than 45 CFM/ft.³ to dry the peanuts to 8 percent

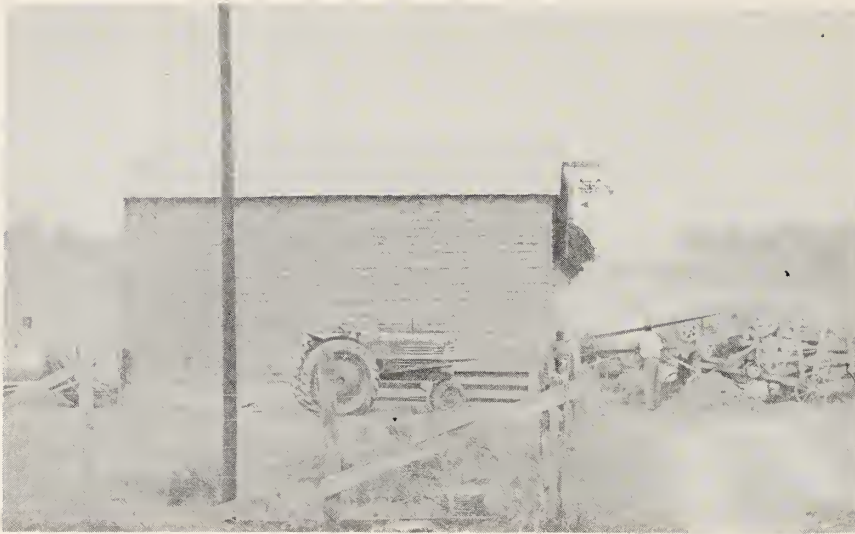


Figure 5. Building used for drying peanuts on the vine. A hayfork is installed to load peanuts in and out.



Figure 6. Multiple-use drying building with bins and floor used for corn, hay, milo, peanuts, and other crops.

moisture at a fuel and power cost of \$4.05 per ton (fig. 6). The quality of turnout as judged by Lummi Peanut Company ^{4/} and the Tidewater Research Station was excellent.

Drying 171 bags of peanuts in the bag gave excellent results. These peanuts were loaded on the drying floor at 20.4 percent moisture and dried with a 9° F. temperature rise on the air (fig. 7). Fuel and power cost amounted to \$1.85 per ton.

1954 CURING STUDIES

Hurricane "Hazel" on October 15 blew the roof from the laboratory, blew the liquid from the manometer gages and delayed the scheduled picking operation of 8 days in the windrow on 1 test to 9 days in the windrow. Laboratory tests were continued under cover of a tarpaulin, and the results of the work were salvaged. Peanuts exhibited a high quality this year.

Windrowing and Drying Effects on Quality

Windrowed peanuts in a repetition of 1953 tests showed substantially the same quality as in 1953. Six-day windrowing showed significantly less shelling damage than 4-day; 8-day windrowing though better than 4, was not significantly better because of the hurricane. The rate of ventilation had no significant effect on shelling damage, germination, or quality. Temperature rise in the bins was not so well controlled as in 1953, the average temperature rises for low, medium, and high flow being 15.2°, 19.7°, and 17.7° F., respectively. The fact that medium flow dropped in quality below low and high flow may be associated with the differences in temperature rise noted. The average of all windrowing tests showed a shelling damage of 8.2 percent as compared to 6.0 percent on the stack pole, a significant difference at the 5-percent level. Commercial-grade windrowed peanuts were as good as and probably better than the commercial-grade stack-poled ones.

Bright hulls of windrowed peanuts were considerably more numerous than those from the stack pole. Excluding the peanuts picked in the mud after the hurricane, the percentage of bright hulled peanuts was 34.2 percent for the windrowed peanuts as compared to 16.8 percent for the stack-poled ones, with a least significant difference of 7.2 percent at the 1-percent level.

Carefully conducted organoleptic tests made by the Human Nutrition Research Division of ARS showed no detectable difference between the windrow peanuts and the stack-poled check.

^{4/} See footnote page 7.



Figure 7. Bagged peanuts stored on a drying floor. Peanuts may be dried in bags on this floor if care is exercised in packing the bags so air will be forced through them.



Figure 8. Conveyor with a belt for peanut handling. Conveyors with chains or augers cause too much damage to the peanuts.

Average moisture losses of 0.37, 0.50, and 0.70 percent (dry basis) per hour obtained with ventilation rates of 5, 10, and 20 CFM/ft.³ agreed very closely with the 1953 figures shown in table 1. The maximum fuel and power cost of \$4.01 per ton occurred when the initial moisture of the peanuts was 26.3 percent and the rate of ventilation was 20 CFM/ft.³, and a minimum cost of \$1.21 per ton was recorded for peanuts having an initial moisture of 18.8 percent when ventilated at a rate of 5 CFM/ft.³.

Miscellaneous Tests

Questions concerning the rate of moisture loss in the windrow led to a study of the problem. In the ordinary range of moistures and evaporation encountered in windrowing peanuts from 4 to 8 days at the Tidewater Research Station a good estimate ($r = 0.95$) of moisture content of the peanuts in the windrow can be made by applying the formula $E + 0.033M = 1.57$, where E = accumulative evaporation in inches of water and M = moisture content on the wet basis. Rainfall increases the moisture making the formula inapplicable when the peanuts receive rain. Using this formula and the expected evaporation for this region, the expected moisture of peanuts windrowed 4, 6, and 8 days is 31.5, 23.6, and 16.0 percent respectively. Rainfall disrupted this expectation and the actual moistures recorded were 35.3, 29.2, and 29.6 percent.

Field trials of peanuts from 5 acres included drying with unheated air flowing at the rate of 28 CFM/ft.³ and use of heated air. The unheated-air experiment worked very well because the peanuts were loaded into the bins at a moisture of 12.6 percent after lying in the field 5 days and 16.2 percent after lying in the field 6 days.

Peanuts from the 5 acres yielded 17,345 pounds of farmers' stock and filled 1,210 cubic feet of space when bulked 6 feet deep at a moisture of 27.6 percent. These peanuts were overdried to 6 percent moisture in a period of 90.8 hours, 55.3 of these hours being with heated air. In spite of overdrying, this bin gave a very acceptable product. One factor which played an important part in the acceptance of these peanuts was the fact that they were excellent peanuts near optimum maturity. One percent moisture variation was noted from the top to the bottom of the pile. A conveyor with a 6-inch belt equipped with flights 1 inch high and 6 inches on center moved 3 tons per hour when run at 500 feet per minute (fig. 8).

1955 CURING STUDIES

Because the laboratory experiments conducted in 1954 confirmed those of 1953, further pursuance of the same line of research was not necessary. New experiments were undertaken to test the use of unheated air, the use of air with 10° F. temperature rise, and the use of a 17° temperature rise at 6 levels of ventilation. This setup proved too thin for effective

statistical analysis of the results obtained. Some of the data gave sound information, but firm establishment of the requirements of ventilation for varying initial moisture levels for both the unheated air and the two temperature rises would require an extremely prolonged period of research under the methods employed in 1955.

Windrowing and Drying Effects on Quality

Quality of windrowed peanuts in this series of tests again showed broad differences because this new line of experimentation was deliberately designed to cross a broad field of drying potentials to discover the most logical lines for concentrated study.

With a 20° F. temperature rise in the drying air (1953 tests), differences in ventilation rates above 5 CFM/ft.³ had a nonsignificant effect on the quality of peanuts, but when the supplemental heat was taken from the drying air, the rate of ventilation had a significant effect on fat acidity. The initial moistures averaged 40.0 percent after 6 days windrowing. This high initial moisture necessitated higher than average ventilation rates with unheated air. An unheated airflow of 16 CFM/ft.³ is required to maintain the fat acidity in an acceptable range, while a 10° temperature rise allowed flows as low as 4 CFM/ft.³.

In 1955 the stack-pole check peanuts were significantly better than the windrowed in both shelling damage and fat acidity. Evidently, the initial moisture of the peanuts placed in the drying bin was too high to give good results. The peanuts were very bright and clean looking when they were loaded into the bin, but the hulls darkened and the quality was hurt in the drying bins. On the average, drying potentials were insufficient to remove enough water to prevent mold damage before drying. At the same time the drying potentials as influenced by temperature rise were sufficient to increase the shelling damage. The temperature effect of the incoming air was highly significant on shelling damage; the higher the temperature the greater the damage. The results of the test illustrate the difficulty in obtaining a high-quality product from high initial moisture peanuts (40.0 percent) by the methods currently employed for crop drying.

Organoleptic tests showed no significant difference in either natural flavors or off-flavors of peanut butter made from peanuts in this test.

Windrowing and Drying Effects on Costs and Returns

Windrowed peanuts (2 acres of peanuts from a 4-acre field) showed a value of \$280 per acre compared to a value of \$256 per acre for peanuts stack poled on 2 acres through the same field in alternate rows. The peanuts came into the drying bin at 30.6 percent moisture (fig. 9). A 5-horsepower drier burning 1.5 gallons of oil per hour for 51 hours and with unheated air for 49 hours dried 10,620 pounds of peanuts for a fuel

and oil cost of \$3.82 per ton. Peanuts used in another test involving 13,000 pounds were wrapped up in dirt and were very wet (45.5 percent) because of unfavorable digging and harvesting conditions. The drier operated 118 hours with a 2.5 gallon per hour nozzle to dry these peanuts to 6.6 percent at an operating cost of \$6.98 per ton. The peanuts from this latter test sold well on the market, but critical analysis of the quality would probably have revealed a substandard product.

At another farm a 1,000-bushel circular steel bin was filled with 12,980 pounds of peanuts at 38.3 percent moisture. These peanuts, 7.5 feet deep, were dried in 151 hours to a moisture content at the top of 10.7 percent and at the bottom of 8.6 percent. Failure to provide sufficient drying potential to the air resulted in some molding of the pods. The drier used in this experiment had provision for needle-valve metering of oil flow to the burner. The operating schedule called for an oil consumption of about 1 quart per hour during the day and about 1 to 1-1/2 gallons during the night. Early in the test one of the experimenters turned the oil flow up high for night and another experimenter turned it down after dark thinking the flow was being increased. This coupled with the low oil consumption during the day, failed to produce enough drying potential to remove water fast enough to prevent molds. The temperature rise varied from about 2° to 10° F. The line of demarcation between the moldy and unmolded peanuts at about 4-foot depth was quite marked. Rate of ventilation at this point was about 19 CFM/ft.³. The fuel and power cost was \$6.82 per ton.

Peanuts from the same field were loaded into unheated-air bins to a depth of 5 feet 2 inches (16,600 pounds) and blown with a 4-horsepower Delco fan for approximately 200 hours. At the later stages of drying the fan was operated only during periods of favorable weather. The top of the peanuts checked 10.1 percent moisture when the fan was cut off, and the entire lot graded at 8 percent. The cost for drying these peanuts with an initial moisture of 36.8 percent was only \$1.42 per ton, and they showed less molding than those held in the heated air bin. The rate of ventilation was only 8.0 CFM/ft.³. This rate under the atmospheric conditions of the test, which were very near to the 10-year average of temperature and wet bulb depression for this area at this season, gave an acceptable product.

At the Tidewater Research Station 8,840 pounds of 33.2 percent peanuts were reduced to 8 percent in 108 hours of operation of a 5-horsepower drier burning 1.5 gallons of oil per hour. The fuel and power cost was \$3.98 per ton and the resulting peanuts were clean, bright, exhibited good milling properties, and were acceptable from every standpoint.

1956 CURING STUDIES

The 1956 season began in a normal manner, but rains starting on October 16 continued through November 3, making it impossible to get

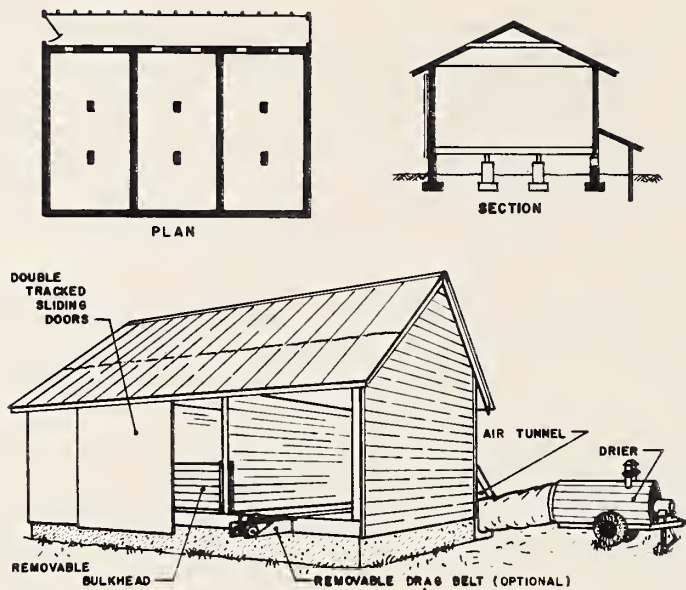


Figure 9. Simple multi-use drying building with unloading drag belt.

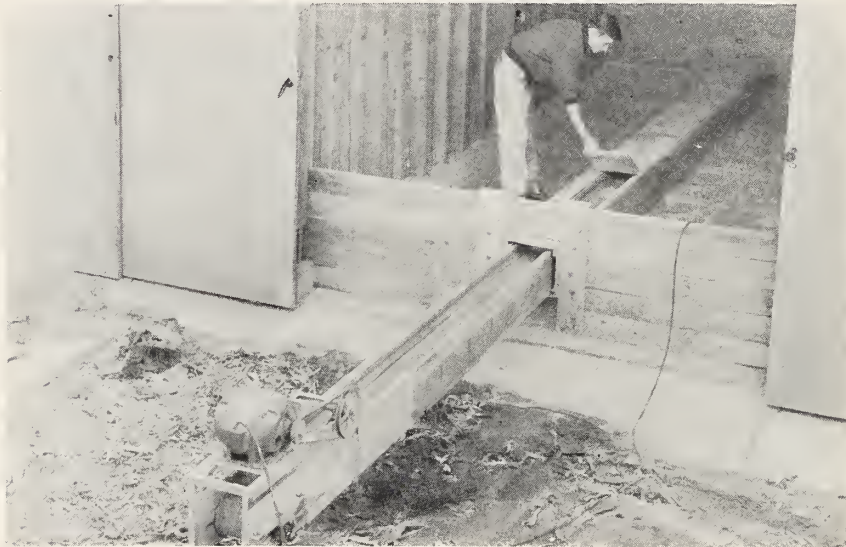


Figure 10. Unloading drag used to convey peanuts from bulk bins.

machinery into the low lying fields during this period. Under these severe conditions of prolonged dampness, peanuts held to the vines for a period of about 15 days, after which the decay of pegs caused peanut shedding which increased to serious proportions before one of the windrowing experiments in the field could be harvested.

Use of Unheated Air

To avoid the difficulty of spreading the laboratory work too thin, the entire utilization of the small test bins was concentrated on determining the best rates of unheated-air ventilation to be used for varying initial moistures of peanuts coming into the bin. Five levels of ventilation and five levels of initial moisture were set up to be tested, with an increasing number of replications as the median points of airflow and moisture were reached. Utilizing the depth increments within bins as a factor in computing the rate of ventilation, airflows at the rate of 2.3, 4.0, 4.6, 6.7, 7.8, 9.8, 11.5, 12.6, 14.7, 15.2, 19.3, 28.5, 41.9, 55.4, and 70.8 CFM/ft.³ of peanuts were studied. (Quality results are not yet available.)

Miscellaneous Field Trials

Field trials were harvested at a moisture content of 27.5 to 33.8 percent from a 17-acre field. The yield on the field was 44,212 pounds on the first picking, and 3,950 pounds from rerunning the hay through the picker. After the vines were picked twice they were raked and baled with a pick-up baler.

To aid in unloading peanuts from the bin an 8-inch drag belt was built to be inserted into a box which corresponds to a shelling trench in ear corn buildings (fig. 10). When operating at 364 feet per minute, the rate of unloading worked very well. To handle shelled corn or any small grain in the drag belt it is necessary to install belt fenders on each side of the trough. The belt fenders fastened to the side of the trough ride on top of the belt and prevent grain from flowing beneath the belt. The 8-inch drag will keep a 6-inch grain auger full when handling shelled corn. This method is considered an economical method of unloading bulk bins when built into a machinery-shed type of drying building. The system loads out at a rate of 6 tons of peanuts per hour.

The only serious loss recorded for the windrow method of peanut harvesting was in a trial of 4.5 acres at the James Rawls farm. Mr. Rawls' peanuts were ready to combine on October 16, but rains started before it was possible to get to the field. Rains delayed harvest until November 6, at which time the vines were almost completely rotted, making the peanut attachment to the vine very weak. An estimated 40 percent of the crop was lost to the hogs, with the other 60 percent yielding approximately 1,500 pounds per acre. The peanuts graded 4 percent damaged. The peanuts were harvested at 28 percent moisture and dried to 8.5 percent.

Mr. John Butler windrowed 12 acres during the rains, but was unable to dig 3 more acres until after the rain on November 6. The peanuts which were freshly windrowed just before the rain started were picked on November 5, and no serious shattering occurred in spite of the fact that these vines lay in a continually wetted condition for at least 15 days. The peanuts picked on November 5 were housed in a 1,000-bushel circular bin with a perforated floor. The initial moisture of 37.8 percent was reduced to 11.8 percent on the bottom and 33.2 percent on the top of the 96-inch depth after 72 hours of operation with a 5-horsepower blower delivering heat from 3 gallons per hour for the first 24 hours and 1-1/2 gallons per hour afterward. At completion of drying the bottom tested 6.4 percent and the top 9.1 percent moisture. The 3 acres which were dug on November 6 were picked on November 7 and delivered to the drier at 50.7 percent moisture. Special consideration was given these peanuts because of the high initial moisture. Unheated air was passed through the mass for the first 16 hours to give a less severe shock in the drying treatment. After that period a 2-gallon-per-hour nozzle was used to complete the drying. Air delivery was high (approximately 30 CFM/ft.³ of peanuts). These peanuts were entirely acceptable from the standpoint of flavor and texture. The theory advanced for the fact that these peanuts were acceptable is that the vines at time of digging had completely lost life and very few living leaves, if any, were present on the plants. It is logical to assume that growth of peanuts had stopped in the soil, and the peanuts had a period of time to ripen before they were dug.

At the O. L. Duke farm two attempts were made to harvest peanuts which were windrowed prior to the rain, but the job of harvesting was not accomplished until October 25 when 1 day of cold, overcast weather with considerable wind dried the windrows and soil sufficiently to allow the machine to pull through the fairly well drained field. These peanuts were dug on October 12 and received some very adverse weather, but they did not shatter when harvested on October 25. They were delivered to drying bins at 33.7 percent moisture and were dried to 9.3 percent with no injury to the quality.

At the experimental farm, 3 acres of peanuts were loaded into a 500-bushel grain bin equipped with a hardware-cloth floor. A fan delivering approximately 1,600 CFM sucked air from beneath this floor. Although the original intent was to leave these peanuts in the field until they were reduced to about 20 percent moisture, it appeared feasible to pick them at 28.6 percent moisture on October 16. When loaded into the bin at a depth of 90 inches, the molding of hulls appeared serious about 4 days after ventilation started. Ventilation was continued for 224 hours at which time the fan was placed on automatic humidistat and thermostat control, which allowed operation only during periods of low humidity and temperature (75 percent, 75° F.). The fan operated 464 hours for the drying job. In spite of serious molding of the pods, the peanut kernels had a bright appearance and graded only 1 percent damaged. No critical

analysis of quality was made. Based on experience with other peanuts, it is judged that the quality of these peanuts was unacceptable from a fat acidity standpoint. The sale price was good.

SUMMARY

The results of 4 years of experimental farm drying of peanuts is given in tabular form on page 21. The bulk density of peanuts going into drying bins varied from 11.4 to 15.1 pounds per cubic foot and averaged 13.5 pounds per cubic foot or 17.0 pounds per bushel. Since the bulk density and air flow resistance were low, the crop was successfully dried at depths of 72 inches. With a temperature rise of 10° F. in the drying air, excellent results were obtained with airflows of 10 to 16 cubic feet per minute per cubic foot of peanuts when the initial moisture was 28 to 31 percent. The cost of fuel and power for drying varied greatly around a mode of about \$3.80 per ton. Products of oil combustion have been noted to give deleterious flavor to peanuts having contact with them. No such deleterious effect has been observed from products of LP gas combustion.

Table II. Results of experiments on the farm drying of peanuts.

Year	Pounds	Bulk Density lb./ft. ³	Depth in.	Initial Moisture % w.b.	Hours to Dry	Vent. Rate CFM/ft. ³	Temp. Rise ° F.	Oil Used gal.	Fuel and Power Cost \$/ton	Results
1953	6,290	15.1	36	27.5	60	45	12	86	4.05	Good
1953	15,580	12.9	72	20.4	30	11	9	75	1.85	Good
1954	-----	-----	48	14.5	60	28	0	----	-----	Good
1954	17,345	14.4	72	27.6	91	10	10	82	2.90	Excellent
1955	10,620	13.9	23	30.6	100	16	10	77	3.82	Excellent
1955	13,210	12.0	32	45.5	130	11	18	----	6.98	Fair
1955	12,980	11.4	90	38.3	151	--	--	235	6.82	Fair
1955	16,600	13.2	62	36.8	197	8	0	0	1.42	Good
1955	8,840	13.6	42	33.2	108	17	10	68	3.98	Excellent
1956	7,690	13.1	90	28.6	465	3	0	0	3.64	Poor
1956	8,146	14.9	42	33.7	51	21	14	102	*7.50	Good

* Small batches increased cost.

CONCLUSIONS

A farmer wishing to reduce the labor of harvest by use of the windrow combine for peanuts can successfully dry the peanuts if they have lain in the windrow for a period of as much as 6 days. Although it may be possible to economically utilize unheated air for drying, sufficient evidence has been amassed to recommend only the use of supplemental heat. Temperature rise, or constant heat injected into the drying air, seems a better system of controlling the drying air than thermostatic control. A 12° to 15° F. temperature rise seems best in the fall of the year although higher temperature rises can be used for drying low moisture peanuts late in the season. The rate of airflow has no significant effect on the quality in the ranges studied if the drying potential is sufficient to prevent molding. With a 12° temperature rise, for peanuts with 40 percent initial moisture, the airflow should not be less than 5 CFM per cubic foot of peanuts. Use of drying facilities for crops other than peanuts is highly recommended.

The following general conclusions regarding the behavior of the Virginia type peanut to various curing environments are made:

- (1) Shelling damage, defined as any peanuts which split or lose as much as one-fourth of their skin coat (testa) in a standardized shelling test, increased with--
 - a. Low moisture content of the kernel.
 - b. Increased temperature to which the peanut was subjected.
- (2) Rate of drying as such did not affect shelling damage.
- (3) Rapid drying did not adversely affect germination.
- (4) Good flavor characteristics were associated with peanuts which had been in the windrow 6 days before they were picked and placed in drying bins. To retain good flavor, a drying potential of at least 0.1 BTU per minute per pound of 8-percent peanuts had to be maintained without heating air above 20° F. above ambient prevailing at harvesttime in Tidewater, Virginia.
- (5) Peanuts harvested from the windrow and dried were, if properly managed, as good as stack-poled peanuts from a standpoint of shelling damage, rancidity, weather damage, and germination, and were better from a standpoint of bright hulls, commercial grade, and yield per acre.

